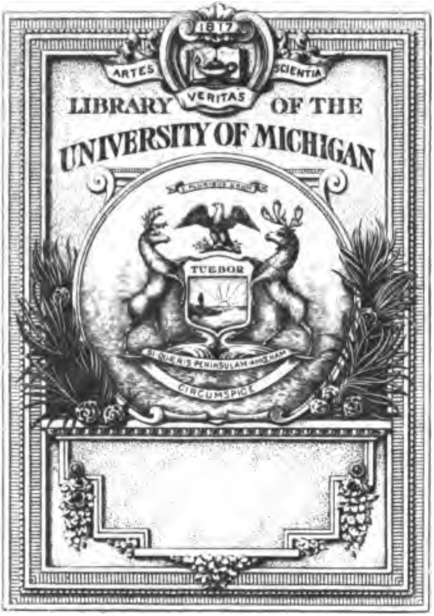

GEOLOGICAL RAMBLES NEAR VASSAR COLLEGE

RAVINE OF HONK CREEK AT NAPANOCH

SOME GEOLOGICAL RAMBLES NEAR VASSAR COLLEGE

BY

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"Tongues in trees, books in the running brooks,
Sermons in stones, and good in everything"

POUGHKEEPSIE
THE VASSAR COLLEGE PRESS
1907

The Lord Baltimore Press
BALTIMORE, MD., U. S. A.

TO

THE MEMORY

OF MY PREDECESSOR

THE LATE PROFESSOR DWIGHT

WHO FOR FORTY YEARS WAS A

STUDENT OF NATURE AMONG THESE HILLS

THIS LITTLE BOOK IS RESPECTFULLY DEDICATED

PERCHED BOWLDER ON BAHRET FARM
NEAR POUGHKEEPSIE

Science
9.11
Mr. Theodore L. Trost
2-24-44

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Map at end of volume.

FELLOW RAMBLERS

Are you aware that the region around Vassar College abounds in manifestations of geologic activity? Where the city of Poughkeepsie now stands was once part of an extensive mountain system which may have rivaled the Alps in grandeur. Of these mountains nothing remains but the stumps, for erosion acting through ages, has cut them down to the roots. Our rocks also, which locally abound in fossil remains of a vanished life, are among the oldest in the country, and the great glaciers, which formerly buried this region under several thousand feet of solid ice, have left most interesting records of their former presence. In the following pages are illustrated and explained some of the more striking geological phenomena which occur in our neighborhood. In these explanations lengthy, technical discussions are avoided, and only the gist of the matter given. There will be no difficulty in finding the localities described, for nearly every one is indicated on the map by a number corresponding to that given in the description, so that any one wishing to make the most of a ramble in the open may plan the excursion which suits the occasion, by comparing the numerals on the map with those in the text. The object of this little book is to draw you closer to the secrets of Nature. Why should you not see and examine for yourself these extraordinary illustrations of Nature's handiwork?

WATERFALLS

Location.—Awosting Falls are situated on the Lake Minnewaska estate at the angle where the road, leading up to the lake leaves the Peters Kill to ascend the mountain. (Outside the area of map.)

Description.—At this point the Peters Kill plunges over a precipice 50 or 60 feet high into a pool beneath, and runs off down the slope to join Rondout Creek in the valley. The precipice, just mentioned, is made up of thin beds of conglomerate lying in a nearly horizontal position, with the upper layers jutting out and overhanging the lower ones.

Explanation.—However the falls may have originated, they are now maintained by undermining. When the view on the opposite page was photographed there was very little water in the Peters Kill, but in the spring and autumn, or after heavy thunderstorms and prolonged summer rains, the creek fills rapidly, and a considerable body of water falls over the precipice. This is what furnishes the power for the erosion and undermining. As the falling water strikes the bottom of the ledge the gravel and bowlders accumulated in the pool are churned up and thrown in every direction. Some of them are hurled against the base of the precipice, and every one which strikes the ledge chips off some of the rock. Thus the effect is to constantly undermine the falls at their base. Higher up in the face of the cliff the layers of conglomerate escape the direct effect of this grinding action of the waterfall, but they are, nevertheless, acted on by the weather, and in time are wedged off by frost or pulled down by gravity. Thus it is that the entire precipice recedes, keeping pace with the rate of undermining at its base, and the waterfall as a whole migrates slowly up stream.

REFERENCES.

An Introduction to Geology. Scott. 1897, pp. 321-324.
Physical Geography. Davis. 1899, pp. 234-237.
Geology. Chamberlin and Salisbury. Vol. 1, 1905, pp. 132-140.

AWOSTING FALLS NEAR LAKE
MINNEWASKA

VANISHED WATERFALLS

LOCATION.—Dover Stone Church is situated at the base of Chestnut Ridge in the town of Dover Plains. The "church" is readily reached by a lane which leaves the main road in the center of the village by the Whalen residence. (Outside the area of map.)

DESCRIPTION.—Five things should be observed at this place: the precipice with the Gothic-like "door" at its base; the large room within the ledge with curved sides, and crevice-like slit in the roof; the brook entering the upper end of this chamber; the shallow valley above the precipice; and finally the deep ravine below it. The precipice, which is about 75 feet high, is composed of garnetiferous mica schist.

EXPLANATION.—Dover Church affords a fine example of the transforming effects of erosion. There was a time, before the chamber and crevice had been opened in the ledge, when the brook leaped from the top of the precipice to the bottom in a picturesque cascade not unlike Awosting Falls to-day. This waterfall at Dover Plains in the early part of its history was located at the mouth of the ravine, but has migrated upstream 300 feet to the present position of the precipice. At this point probably a joint or crack in the schist occurred, running in the direction of the stream, and well down into the body of the ledge. This slight opening was seized upon by the water, and gradually enlarged, precisely as has already been described in the section on Crevice Cutting. This slit grew to a crevice, and was cut with constantly widening sides to the base of the precipice, letting out the water beneath the falls, diverting the stream, and destroying the cascade.

REFERENCES.

Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 150-154.
Physiography. Salisbury. 1907, pp. 161-163.
Elements of Geology. Norton. 1905, pp. 46-48.

STONE CHURCH AT DOVER PLAINS

RAVINE CUTTING

LOCATION.—This ravine occurs at Marlboro, about 100 feet east of the River road where Wrights Creek plunges over a steep precipice to the level of the Hudson River. (Number on map, 1.)

DESCRIPTION.—Wrights Creek, after crossing the road, divides into two parts. The main branch flows for a short distance through a rocky channel, and then leaps abruptly into the bottom of the ravine 100 feet below. The other branch is a mill-race, and after passing through a turbine of a factory, falls over a precipice, a little to the north of the main waterfall.

EXPLANATION.—In the article on Waterfalls it was shown how a cascade changes its position, and migrates up stream, and in the section on Vanished Falls it was explained how, in this process of recession, a ravine was left behind to mark the line of retreat. The ravine at Marlboro is of this nature and origin. There was a time, not very remote in a geological sense, when it did not exist. The cascade of that time was located where the ravine now opens. This was doubtless just after the glacier disappeared from the Hudson Gorge. The waterfall had not been flowing long before it began to recede. In its backward movement it naturally followed the channel of the stream above, and consequently the form of the ravine would be a rough copy of that course. By examining the ravine on the ground it will be seen that it is curved at right angles. This indicates that the stream took that path before reaching the original cascade. As the falls continue their retreat toward the road, the ravine will gradually grow in length, and assume an S shape. The origin of the ravine of Honk Creek, shown in the frontispiece is similar.

REFERENCES.

Elements of Geology. Le Conte. 5th ed. 1904, pp. 12-15.
Elements of Geology. Norton. 1905, pp. 59-62.
Geology. Chamberlin and Salisbury. Vol. III, 1906, pp. 417-419.

FALLS AND RAVINE OF WRIGHTS CREEK
AT MARLBORO

STREAM EROSION

LOCATION.—The phenomena discussed below may be observed in the Peters Kill on the Lake Minnewaska estate, where the road winds along the creek a quarter of a mile below Awosting Falls. (Outside the area of map.)

DESCRIPTION.—There are two things to note in the figure opposite, one is the mass of huge bowlders heaped together at a bend in the stream, and the other is the rounded appearance of these blocks.

EXPLANATION.—This heap of stones is the sandpaper with which the torrent scrapes out and erodes its bed. At the time the photograph was taken the stream was low and idle, but in the spring, during freshets and high water stages, conditions are quite different. At such times the torrent exercises its full force, the current is swift, and the power to push objects along the bottom rises rapidly with the increase in the velocity of the water. Then it is that the stream does its work. Huge bowlders that look immovable are bumped and shoved along, smaller blocks are driven forward at a more rapid rate, while sand and small pebbles are carried onward in suspension. All are forced by the current down stream toward the valley below. But a bowlder cannot scrape along the bottom without rubbing some rock powder from the stream bed, and smaller particles will likewise scour every time they come in contact with bedrock. Thus it is that a valley is carved out of the mountain side. In course of time this infinitesimal abrasion adds up to a large sum. When this photograph was taken the Peters Kill was resting from its labors but its graving tools are at hand ready for use during the next freshet.

REFERENCES.

An Introduction to Geology. Scott. 1897, pp. 96-100.
Elements of Geology. Le Conte. 5th ed. 1904, pp. 10-12.
Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 119-123.

EROSION TOOLS IN THE PETERS KILL NEAR LAKE MINNEWASKA

HUDSON GORGE

LOCATION.—This view was taken at the end of the New York, Ontario and Western Railroad pier near Cornwall Landing. It shows the northern gateway to the Highlands. (Number on map, 2.)

DESCRIPTION.—From New York to Albany the Hudson flows in a deep steep-sided channel so that the surface of the river lies from 150 to 300 feet below the general level of the surrounding region. Borings made in the river at the northern entrance to the Highlands, have gone down nearly 500 feet below the surface of the water through silt and bowlders without reaching rock-bottom.

EXPLANATION.—At a time now very remote in geologic history, this region stood at a much lower elevation than it does to-day. It was in fact so near sea-level that the rivers which drained it were sluggish, and instead of cutting downward swung laterally in their courses and widened their valleys. Then there came an uplift. The region was slowly raised, and the rivers received new energy. Instead of widening their valleys they deepened their channels, and the higher the region rose the deeper they cut them. One of the rivers so affected was the Hudson. In the midst of its broad valley it cut a narrow steep-sided cañon not unlike the Grand Cañon of the Colorado in character, although not equal to it in grandeur. When the Ice Age came on the glaciers widened and deepened this cañon somewhat, and when they melted away left it choked with debris. This has since been removed to some extent, but the general subsidence of the region has admitted the ocean water, so that the Hudson has been changed from a torrent to a navigable river, and the cañon character of the valley transformed to that of a fjord.

REFERENCES.

Elements of Geology. Le Conte. 5th ed. 1904, pp. 15-18.
Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 92-100.
Physical Geography. Davis. 1899, pp. 239-262.

HUDSON GORGE NEAR CORNWALL LANDING

POT-HOLES

LOCATION.—The locality described here is half way between East and Hyde Parks, on the southern of the two connecting roads, where Crum Elbow Creek is crossed by a bridge, near the old mill. The pot-holes extend along both banks of the stream from the bridge to the falls at the mill dam. (Number on map, 3.)

DESCRIPTION.—The pot-holes at this locality vary in size from that of a teacup to a soup kettle. In the figure they lie in the middle foreground, and impart a rough, cavernous appearance to the ledge which rises above the water at this point.

EXPLANATION.—Pot-holes are excavated by grains of sand and pebbles which are swept along by the current. and kept in constant motion by the water. When a ledge crosses the path of a stream the little irregularities on the surface cause slight eddies in its current. Particles of sand caught in these eddies on their way down stream are swirled around, scrape off some rock powder from the side of the hollow, and pass on. Others follow in quick succession, each one removing an infinitesimal amount of the rock. Thus the original insignificant cavity grows constantly larger, and with its increase in size exerts a greater influence on the detritus swept along by the current. Sand grains soon give place to pebbles, and they in turn to cobbles and small bowlders, which are whirled round and round in the enlarging pot-hole, cutting it deeper and wider as time goes on. The pot-holes in the ledge above high water mark show where the stream used to flow before it had cut to its present level. They were likewise once under water, but have been left behind as the stream has cut its bed deeper.

REFERENCES.

Geology. Chamberlin and Salisbury. Vol. I, 1905, p. 140.
An Introduction to Geology. Scott. 1897, p. 330.
Text Book of Geology. Geikie. 3rd ed, 1893, pp. 385-386; 4th ed. 1903, pp. 497-498.

POT-HOLES NEAR EAST PARK

CHASM CUTTING

LOCALITY.—This is illustrated at Dover Wells, in the town of Dover Plains. The "wells" lie on the side of Chestnut Ridge, about 500 feet above the valley, and may be reached by following the main road southward through the village to a lane which crosses a railroad and runs toward the ridge, just beyond Valley View Cemetery. (Outside the area of map.)

DESCRIPTION.—These wells consist of a chasm about 30 feet deep and 10 feet wide which lies along a mountain stream as it descends from Chestnut Ridge. The chasm at intervals of every 10 or 20 feet is enlarged into round basin-like hollows which resemble huge potholes with their partitions broken out.

EXPLANATION.—As the brook cut its way into the mountain side it probably encountered a crack or joint in the bed-rock. This was a point of weakness which was immediately attacked and enlarged by the current until it was cut to many times its original size. This stream had hardly sunk its bed along the joint-plane when it began to swing in sharp angles, first against one wall and then against the other. As the channel was narrow, and the current swift, these deflections rapidly impressed themselves on the soft rock, by cutting out circular basins like a series of connected pot-holes. These basins once started tended to augment and perpetuate themselves. In times of flood the torrent rushes down the mountain side, and on reaching the basins dashes around in them with a swift vortex-like motion, grinding at the sides with the bowlders and pebbles which it is carrying with it on its way to the valley below. Thus the basins grow wider as the channel sinks deeper.

REFERENCES.

Elements of Geology. Le Conte. 5th ed. 1904, pp. 24-25.
Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 190-194.
Physical Geography. Davis. 1899, pp. 239-246.

DOVER WELLS NEAR DOVER PLAINS

ROCK-WEATHERING

LOCATION.—This process is illustrated among the old weather-beaten rocks in the south wall of the Clinton Point Stone Company's quarry at Stoneco, about a mile and a quarter south of Camelot. (Number on map, 4.)

DESCRIPTION.—The rock is a gray limestone covered with a network of fine veins, which stand out in relief from the face of the ledge, resembling filigree work on a grand scale, and dividing the surface into small rectangular hollows.

EXPLANATION.—This example of weathering is an illustration of the dissolving power of the atmosphere. Two things are to be explained: the structure of the limestone, and the action of the atmosphere. If the ledge is examined carefully, especially on the surfaces which are not extensively weathered, it will be seen that the body of the rock is traversed by minute yellowish-white veinlets of calcite, which cross each other in all directions. Their origin dates well back in the history of the earth. At one time this limestone ledge was deeply buried in the earth's crust, and subjected to such great pressure that its elastic strength was surpassed, and it broke up into a thousand fragments. Later circulating underground waters bound these fragments together by depositing calcite in the interstices. After the lapse of many ages erosion stripped off the overlying rock, and exposed the limestone to the action of the atmosphere. A change now slowly took place. Chemical reagents contained in the atmosphere attacked the limestone and calcite, and transformed them into substances which were dissolved and carried away in rain water. The limestone, however, yielded more readily than the calcite, hence the latter stands out as ridges, and the former lies in the hollows between them.

REFERENCES.

An Introduction to Geology. Scott. 1897, pp. 72-80.
Rocks, Rock-weathering, and Soils. Merrill. 1897, pp. 176-186.
Elements of Geology. Le Conte. 5th ed. 1904, pp. 6-8.

WEATHERED LIMESTONE AT STONECO

ROCK BREAKING

LOCATION.—The illustration on the opposite page shows the rock debris beneath the western wall of Skytop at Lake Mohonk. A trail leading to the "crevice" passes over this pile of rocks. (Number on map, 5.)

DESCRIPTION.—The rocks which are composed of quartz conglomerate are prevailingly of considerable size, many of them weighing 100 tons or more, and are wedged together at all angles in great confusion, forming many caverns and moss-covered grottoes.

EXPLANATION.—Skytop is a ledge of tough, white, quartz conglomerate, which is slowly crumbling before the attack of the elements. If the cliff is given even a superficial examination it will be observed that the rocks are everywhere traversed with cracks or partings known as joints. These joints are filled with moisture especially during the spring and autumn seasons, and as cold weather approaches, the water within them is converted into ice. Expansion consequent on freezing exercises great lateral pressure on the containing walls, like water frozen in a pipe. Thus the sides of these joints are forced apart, allowing more water to collect ready for the next freeze, and a still further expansion. As soon as an opening is made the roots of trees and other plants aid this work of destruction; for, by following down the crevices in search of moisture, they grow and expand from year to year, slowly wedging the rocks apart and holding them open. The result of all this is to loosen blocks from the cliff, and cast them down to accumulate at its base. The ridge is, therefore, constantly growing less and less, and in time will disappear altogether.

REFERENCES.

An Introduction to Geology. Scott. 1897, pp. 80-84.
Text Book of Geology. Geikie. 3rd ed. 1893, pp. 313-314; 4th ed. 1903, pp. 531-532.
Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 44-50.

ROCK BREAKING AT LAKE MOHONK

ROOT WEDGING

LOCATION.—This ledge is located near the little hamlet of Enterprise, opposite the old Traver homestead. (See page 46.) The cluster of trees shown in the illustration is on the west side of the ledge. (Number on map, 6.)

DESCRIPTION.—These trees are all growing from a single set of roots which have taken firm hold of the rock by wedging themselves down into the joints. The oldest individual is seen in the rear of the group, and the other bushes are all suckers which have started up from the parent roots.

EXPLANATION.—Wherever ledges lie close to the surface, and are covered only by thin soil, trees are apt to send their roots down through the soil-cap, and penetrate the ledge beneath. All rocks are intersected by a system of cracks known as "joints." Near the surface these openings are pried open by frost action, and in time are filled with dirt. Conditions are then favorable for supporting vegetation, and sooner or later a seed of some forest tree will lodge and germinate there. The tiny rootlets quickly penetrate the thin soil, and work their way downward into the joints, in search of food and moisture. Delicate as this invasion is in its early stages, it soon grows to serious proportions, for the roots rapidly expand, and force the sides of the joint apart, disrupting the massive rock and wedging it asunder. This action is known as the "wedge-work of roots" and is regarded as an important factor in erosion. In a level country the effect of root work is not appreciated, but in rugged regions, and where there is a forest growth at the top of a precipice, the results of rock breaking in which roots have taken a conspicuous part, may be seen in the heaps of debris at the base of the cliffs.

REFERENCES.

Rocks, Rock-weathering, and Soils. Merrill. 1897, pp. 201-202.
Physiography. Salisbury. 1907, pp. 76-78.
Text Book of Geology. Geikie. 3rd ed. 1893, p. 473; 4th ed. 1903, p. 600.

ROOT WEDGING NEAR ENTERPRISE

RESISTANT STRATA

LOCATION.—This phenomenon is illustrated in the cliffs at Lake Minnewaska, and at Lake Mohonk. Of these the latter is discussed here because of its more ready accessibility. (Number on map, 5.)

DESCRIPTION.—The cliff shown in the view is composed entirely of a white quartz conglomerate resting on a soft, brown shale. The latter may be seen along all the eastern face of the mountain, as one ascends from the valley of the Wallkill.

EXPLANATION.—When these rocks were raised above the ocean they were composed of both hard and soft strata lying one upon the other. In these beds the future topography of the region lay dormant, as it were, ready to develop as erosion should call it into expression. Two factors were at hand; the passive resistance of the rocks, and the active attack of erosion. Their interaction has produced the present topography. The floor of the Wallkill valley, for instance, is soft shale which has succumbed rapidly to the effects of erosion, with the obvious result. There is a valley for the Wallkill now because there was a shale deposit there earlier. Conversely, the cliffs at Minnewaska and Mohonk are conglomerate, which has resisted erosion more successfully than the shales, and therefore stands out in relief. There is a Shawangunk Range now because there was a conglomerate there before it. In a similar manner such prominences as the Catskill, Adirondack, Marlboro, Stissons, Fishkill, and other mountains in this vicinity are to be explained. They are simply unreduced, resistant beds standing as ridges above valleys of softer rocks, which have yielded more readily.

REFERENCES.

Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 140-150.
Physiography. Salisbury. 1907, pp. 168-173.
Practical Physiography. Fairbanks. 1906, pp. 142-151.

SKYTOP AND CLIFFS AT LAKE MOHONK

LIMESTONE CAVERN

LOCATION.—This cavern is situated on the farm of Alfred Welch, in Eighmyville, in a low ridge near the junction of the Enterprise and Rhinebeck roads. (Number on map, 7.)

DESCRIPTION.—The opening shown in the illustration leads downward into a series of low chambers and passages which have been excavated in the midst of a massive limestone. Stalactites and stalagmites occur throughout the cavern.

EXPLANATION.—When rain soaks into the soil it comes in contact with large quantities of organic acids arising from the decay of vegetable and animal remains. These acids are dissolved, and carried downward by the descending rain water, penetrating all the cracks and partings of the rocks beneath, and even saturating the body of the rocks themselves. No rock is able to withstand the solving action of these humic acids. All are dissolved in some degree, and limestone is probably the most readily affected. As this rock passes little by little into solution, it is carried away by circulating underground waters, conducted through long winding subterranean passages, and finally issues at the surface as springs. When this action is continued century after century an appreciable excavation is made in the body of the limestone, and cavities begin to take the place of the solid rock. These openings admit larger supplies of water, which produce more chemical solution, and a further removal of the limestone. Thus cracks enlarge to cavities, and cavities gradually expand to caverns. Such huge openings as the Mammoth Cave of Kentucky or the Luray Caverns of Virginia were formed by the solution of limestone in exactly the same manner as this little grotto at Eighmyville.

REFERENCES.

An Introduction to Geology. Scott. 1897, pp. 88-92.
Physical Geography. Davis. 1899, pp. 224-226.
Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 226-228.

ENTRANCE TO CAVERN AT EIGHMYVILLE

STALACTITES AND STALAGMITES

LOCATION.—In the limestone cavern on the Welch estate at Eighmyville, discussed on the previous page, there are a number of places where stalactites and stalagmites are now in the process of formation. (Number on map, 7.)

DESCRIPTION.—In the figure pendant columns and corrugated surfaces of lime carbonate may be seen hanging like icicles from the roof of the chamber. These are the stalactites. The large pillar which occupies the middle of the illustration is caused by the union of stalactites descending from above and stalagmites growing upward from below until they have grown together into a solid mass.

EXPLANATION.—When the work of dissolving limestone, described on the previous page, has gone on long enough to produce appreciable cavities, water still continues to filter through the cracks in the limestone. and drip on the bottom of the opening. These drops contain minute quantities of lime in solution, and as soon as they issue from the crevices in the roof, even while the drop is collecting, this lime starts to precipitate in the form of calcite, a mineral composed of the carbonate of lime. Before the drop falls a little film of calcite has collected on the roof of the cavern to grow and enlarge like an icicle with every succeeding drop, until a long pendant or stalactite is formed. The drop again on falling descends in a perpendicular line, and strikes the ground immediately beneath the growing stalactite above. Here it precipitates another film of mineral, repeating the process with every drop until a column of calcite or stalagmite slowly rises to meet the descending needle overhead and form a pillar.

REFERENCES.

Elements of Geology. Le Conte. 5th ed. 1904, pp. 77-78.
Text Book of Geology. Geikie. 3rd ed. 1893, pp. 365-366; 4th ed. 1903, p. 475.
Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 228-229.

STALACTITES AND STALAGMITES AT
EIGHMYVILLE

BEACH SHINGLE

Location.—The beach figured here occurs on the western shore of the Hudson one-half mile south of Cornwall Landing. (Number on map, 2.)

Description.—This beach is made up almost exclusively of coarse stones and cobbles, and is situated at a slight bend in the river, so that there is an unbroken surface of water stretching for five miles or more toward the north. During severe northeast storms waves accumulate considerable power in crossing this open water and break on this shore with much force.

Explanation.—A deposit of coarse beach gravel is known among geologists by the name of "shingle." Such a formation is the result of waves working on material along the shore, and is an expression of the force of the breakers. When the Hudson is calm or disturbed only by small waves, the effect of these undulations is insignificant. But when high winds sweep down the length of the river they have abundant opportunity to churn up respectable waves and these, breaking on the shore, produce the shingle. A beach free from the attack of waves would normally consist of coarse and fine material mixed together in great confusion. The effect of waves would be to separate the coarse from the fine and deposit each by itself. When breakers are powerful enough this sorting process is carried forward with great precision. Loose material is washed and rolled about, all the fine silt and sand is separated from the coarse stones, carried out by the undertow to deeper water and deposited, while the cobbles are left behind on the beach as shingle. This is exactly what has occurred here and essentially the same process takes place on the margin of a lake and along the shore of the ocean.

REFERENCES.

Manual of Geology. Dana. 4th ed. 1895, pp. 209-216.
Elements of Geology. Le Conte. 5th ed. 1904, pp. 34-39.
Elements of Geology. Norton. 1905, pp. 162-163.

BEACH SHINGLE NEAR CORNWALL LANDING

STREAM TRANSPORTATION

Location.—The figure opposite was taken from the carriage bridge over Moodna Creek, three miles south of Newburg on the direct road to Cornwall. (Number on map, 8.)

Description.—The feature of special interest in this illustration is the deposit of sand and gravel exposed by the low water of the stream. The gravel is coarse and well rounded and deposited across the entire breadth of the creek.

Explanation.—A stream is constantly procuring detritus from its entire basin and carrying it out to the sea. This act of moving material downward is known as transportation. The power of transportation varies with the velocity of the current. The swifter the stream the greater the load it can carry, therefore, the greatest amount of work is done in times of high water. This principle is illustrated after every summer shower, when a stream, usually clear, becomes turbid with mud in process of transportation. When streams are most active they are usually so muddy that it is impossible to see what is going on beneath the surface. In swift streams, however, it is sometimes possible to hear bowlders and cobbles knocking together if the ear is placed on the bottom of a boat floating on the water. If the current should slacken so as to become sluggish, then the load would be dropped and the water clarify. Under such conditions a glance at the bottom would show what sort of materials were being transported. But a still easier method of study is afforded in the present case, where not only is the load dropped for a time, but the stream itself has lowered so as to expose the detritus to view. There is no occasion to describe this deposit in detail.

REFERENCES.

An Introduction to Geology. Scott. 1897, pp. 100-103.
Elements of Geology. Le Conte. 5th ed. 1904, pp. 18-21.
Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 115-119.

RIVER TRANSPORTATION NEAR NEWBURG

STREAM DEPOSITION

LOCATION.—The view on the opposite page shows the mouth of Wappinger Creek. It was taken near the draw-bridge, half a mile east of New Hamburg. The camera was pointed up the stream towards Wappinger Falls. (Number on map, 9.)

DESCRIPTION.—For some distance above the draw-bridge the waters of the creek are sluggish and ponded by the Hudson. The lily flats, shown in the foreground of the illustration, are accumulations of mud and sand deposited in quiet waters of the creek until they have filled up the greater portion of its bed, leaving only a narrow channel still open to navigation.

EXPLANATION.—The capacity of a stream to do work is dependent on the force of its current. Other things being equal, a swift stream does more work than a sluggish one, and does more in those portions of its valley where it is moving rapidly than in sections where it is moving slowly. For the purposes of convenience, a stream may be considered as doing three things: eroding, transporting, and depositing. The first of these activities was discussed in the section on Stream Erosion. It is most active where the current is swiftest. The second was considered in the section on Stream Transportation, and of the third there is an example furnished here at the mouth of Wappinger Creek. All the material which a stream secures by erosion must either be transported or deposited. Below Wappinger Falls the load is dropped, and on being deposited fills the channel. In the case of Wappinger Creek the tendency will be for the marshes at the side to encroach steadily on the open channel in the center, until it is reduced to a narrow stream just sufficient to carry out the drainage of the Wappinger basin.

REFERENCES.

Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 181-190.
Physiography. Salisbury. 1907, pp. 179-187.
Practical Physiography. Fairbanks. 1906, pp. 197-208.

DEPOSITION IN WAPPINGER CREEK NEAR NEW HAMBURG

CROSS-BEDDING

LOCATION.—The illustration given here is taken from Flagler and Allen's pits at Arlington, about one-eighth of a mile northeast of the Vassar College Campus. The observer should look for a fresh section. (Number on map, 10.)

DESCRIPTION.—A cursory examination suffices to show that the material in each bed is quite uniform in size, but that the different layers vary greatly among themselves in this respect. A lens of clay may be surrounded with coarse sand, or vice versa, and the different beds lie at all angles, truncating and interfering with each other in great confusion.

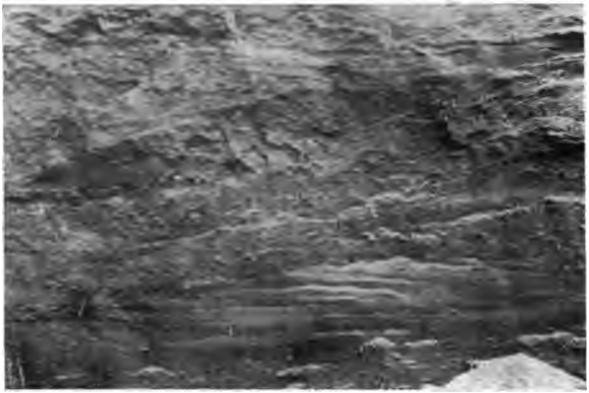
EXPLANATION.—This formation is the result of water action. The plain surrounding Arlington and Vassar College was built up, during the latter part of the Ice Age, by sediments obtained from the surrounding hill country, and deposited here through the agency of running water. An old valley was thus filled in and leveled up to the present surface of the plain. Running water has the power of transporting material in proportion to its velocity. The greater the rapidity of the current, the heavier the load it can carry and the larger the fragments it can push along. Whenever, therefore, the velocity of a stream is checked, a portion of its load is deposited, and when it is accelerated additional load is picked up. The cross-bedded confusion of the layers in this pit, consequently, is a record of the varying currents of a vanished river. When its current was checked the stream deposited a part of its load at various angles, and when freshet conditions prevailed it scoured out some of the sediments already deposited, carried them away and left coarser materials in their place.

REFERENCES.

Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 194-196.

Text Book of Geology. Geikie. 3rd. ed. 1893, pp. 501-502; 4th ed. Vol. I, 1903, pp. 636-639.

An Introduction to Geology. Scott. 1897, p. 224.



CROSS-BEDDING IN FLAGLER AND ALLEN'S PITS AT ARLINGTON

FLOOD-PLAINS

LOCATION.—This photograph was taken in front of a little cottage on the west side of the Wallkill, just beyond the point where the road to Lake Mohonk leaves the road leading down to Libertyville. (Number on map, 11.)

DESCRIPTION.—Two things should be noted in this locality: the broad flat in which the Wallkill flows, and the high steep banks on either side. The flat, which is a mile or more in width in the vicinity of New Paltz, is the flood-plain. On either side of this plain the banks rise rapidly, terrace fashion, to a narrow flat about 50 feet above the lower one.

EXPLANATION.—When the ice-cap, which invaded this region from the north, began to melt back it supplied this valley with a great quantity of water, and to the river thus formed, it surrendered an immense amount of rock debris, which had been secured from the surrounding country. Such a load of sediment was more than could be carried, consequently the stream was obliged to deposit the greater part of it along its course. As this was continued from year to year the valley gradually filled up with sand and gravel, which was stored by the stream, until such time as it could find an opportunity to transport it seaward. Such is the origin of the upper flat of sand and gravel. It originally extended across the Wallkill valley, and dates back to the Ice Age. An opportunity to remove this detritus did not present itself until the ice had disappeared from this region. Then the Wallkill, although much reduced in volume, had less sediment to carry, and could, therefore, begin to cut out what it had previously stored. The lower plain indicates how far this work of erosion has proceeded.

REFERENCES.

Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 305-307.
Physiography. Salisbury. 1907, pp. 187-189.
Practical Physiography. Fairbanks. 1906, pp. 333-337.

FLOOD PLAIN OF THE WALLKILL NEAR NEW PALTZ

GLACIATED SURFACE

LOCATION.—The ledge shown here is situated on the south side of the Wurtemburg road one-half mile due south of Enterprise, in a pasture opposite the old Traver homestead. (Number on map, 6.)

DESCRIPTION.—This ledge is oval or lens-shape, about 15 feet high at the top of the ridge and 200 feet long. The lenticular form, together with the smooth and striated surface, is highly characteristic of glacial erosion.

EXPLANATION.—When the glaciers invaded this region during the Ice Age, they encountered ledges with rough, angular surfaces and gradually overrode them as the ice margin crept slowly southward. Clean ice of itself is able to do very little erosive work, but when the bottom of a glacier is covered with bowlders which it has picked up and frozen tightly into its mass, it is armed with effective cutting tools and acts like a gigantic piece of sandpaper on rock surfaces beneath it. Such, in brief, was the method employed by the ice in reducing exposed ledges. Rough corners and sharp angles could not long withstand the gouging and planing action of these bowlders, when pressed down and driven forward by the enormous weight of the overlying ice. Wherever bowlders came in contact with a ledge they gouged into its surface and left long grooves or striations behind, and whenever fine sand or rock flour passed over the rock it imparted a rough polish. When the ice retreated and left this region bare once more, smooth rounded surfaces were everywhere to be seen, rugged, angular peaks and precipices had disappeared. Such a topography is characteristic of a glaciated country, and this district still retains the contour imparted to it by the ice-cap.

REFERENCES.

An Introduction to Geology. Scott. 1897, pp. 110-113.
Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 304-305.
Physiography. Salisbury. 1907, pp. 242-251.

GLACIATED LEDGE NEAR ENTERPRISE

GLACIER STRIÆ

LOCATION.—These striæ occur on a ledge located at the southeast corner of Cherry Street and College Avenue, Poughkeepsie, immediately in the rear of the estate of Mr. Smith L. DeGarmo. (Number on map, 12.)

DESCRIPTION.—This ledge has a smoothed, rounded, and subdued surface, while much of it has received a low polish. Around the lower portions of the ledge the surface is covered with minute scratches, roughly parallel with one another and running in a general north and south direction. These are the glacier striæ.

EXPLANATION.—These striæ were made by the ice and date back to the Glacial Epoch. When the great ice-cap crept down over this region it scraped up and removed, in one way or another, the loose rocks and much of the soil-cap, which had previously covered the surface of the country. This debris was frozen in the solid ice and carried along with it on its southward journey. Clear ice, of itself, will not scratch the surface of a ledge. But when charged with sand, gravel, and angular blocks of stone it is armed with cutting tools of great power. The entire bottom and sides of such a glacier become, as it were, a huge planing machine. As it moves slowly along over the country the rocks are scraped and gouged incessantly, year after year and century after century, so that all the rough angular parts are removed and the whole surface reduced to a form with smoothed and rounded contours. The ice-cap has long since melted back and disappeared, but the signs which it has left are everywhere to be seen. On this ledge it has left two characteristic and important records. The first of these is the subdued rounded surface as a whole, and the second is the scratchers or striæ.

REFERENCES.

Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 283-285.
An Introduction to Geology. Scott. 1897, pp. 110-113.
Glaciers of North America. Russell. 1897, pp. 19-21.

GLACIER STRIÆ ON CHERRY STREET IN POUGHKEEPSIE

ERRATIC BOWLDERS

LOCATION.—These erratic bowlders are in a field in plain sight from the highway, about one and a half miles west of New Paltz, near the point where the road leading to Lake Mohonk branches off from that going to Lake Minnewaska. (Number on map, 13.)

DESCRIPTION.—The bowlders are angular blocks of white quartz conglomerate overgrown with brown lichens, which give to the surface a mottled appearance. Although they are all more or less buried in the soft soil, it is evident that they weigh several tons apiece and the largest must attain five feet in height.

EXPLANATION.—The country rock, or the rock which is found underlying this region, is a dark brown shale. The bowlders, on the other hand, are white quartz conglomerate and bear no stratigraphic relation to the shales beneath. They do not normally belong where they are. They are strangers or erratics, and their presence here calls for an explanation. On the hilltops to the west and northwest can be seen great cliff-like ledges made out of the same material as constitutes these erratics. There the conglomerate is in its natural stratigraphic position and these bowlders once formed part of the cliffs. They have, therefore, been transported from their parent ledge in the Shawangunk Mountains to their present position, and the agents of transportation were the glaciers of the Ice Age. When these glaciers covered this region to a depth of several thousand feet they completely overwhelmed these mountains and buried them entirely from view. On their slow march southward from Canada, they plucked these blocks from the parent ledges, carried them away, and finally on melting, left them stranded in their present position.

REFERENCES.

An Introduction to Geology. Scott. 1897, pp. 153-156.
Geology. Chamberlin and Salisbury. Vol. III, 1905, pp. 340-341.
Text Book of Geology. Geikie. 3rd ed. 1893, pp. 425-427; 4th ed. 1903, pp. 553-556.

ERRATIC BOWLDERS NEAR NEW PALTZ

PERCHED BOWLDER

LOCATION.—The bowlder is situated on the farm of Mr. G. H. Bahret, about a quarter of a mile to the rear of the farm-house. The Bahret farm is on the second road to the east of the Hudson River State Hospital, just at the point where Fallkill Creek crosses at a turn in this highway. (Number on map, 14.)

DESCRIPTION.—The bowlder is about eight feet high, twelve feet long, five feet thick, and weighs probably twenty tons or more. It is composed of sandstone, is angular, and stands upright on its narrow edge, supported by three or four points, on a pedestal-ledge of sandstone. The figure facing the table of contents gives another view of this bowlder.

EXPLANATION.—This bowlder was obtained from a ledge, probably not far distant, and brought to its present position during the Glacial Epoch by the great ice-sheet, which formerly covered this region to a depth of many thousands of feet. As this ice moved forward it picked up gravel and bowlders and carried them along with it, precisely as the glaciers of Greenland and the Alps are doing to-day. On the melting of the ice, at the close of the Ice Age, this bowlder was lowered slowly from its position in the ice to the ground, and came to rest on the ledge which chanced to lie directly beneath it. The process of lowering this bowlder to its present position was more delicate than if it had been accomplished by means of a block and fall. An examination of this rock will suffice to show that it is yielding to the influence of the weather and crumbling away. In time the supporting points will decay, when the bowlder will roll over to the ground and assume a position of more stable equilibrium than that in which it now rests.

REFERENCES.

An Introduction to Geology. Scott. 1897, pp. 54-55.
Text Book of Geology. Geikie. 3rd ed. 1893, pp. 425-427; 4th ed. 1903, pp. 553-555.
Elements of Geology. Le Conte. 5th ed. 1904, p. 57.

PERCHED BOWLDER ON BAHRET FARM NEAR POUGHKEEPSIE

GLACIAL TILL

LOCATION.—This deposit occurs on the southern side of the road leading to Highland from the water front, at a point about 100 yards below the grist mill belonging to Philip Schantz (Number on map, 15.)

DESCRIPTION.—In this bank, coarse and fine materials are mixed together. Bowlders, polished and covered with glacial striæ, are imbedded in a drab clay, without regard to size and with no definite arrangement.

EXPLANATION.—When the glaciers invaded this region from the north at the beginning of the Ice Age they in all probability encountered a country covered with a deep soil-cap, and only occasional outcrops of rock in stream valleys and along mountain escarpments. With the advance of the ice-sheet this loose material was stripped off and the ice brought in contact with bare rocks. Abrasion and scouring was accomplished by means of the stones and bowlders which the ice picked up and grasped in its solid mass along its bottom and sides. With these tools it scratched, gouged, and polished the rocks over which it passed and in turn, the stones employed to do this work were themselves striated and polished. This constant erosion produced vast quantities of rock debris which the glaciers from time to time deposited. But their method of deposition was very different from that of a stream and crude in comparison. A stream by means of its delicate currents can sort and assemble particles of uniform size but a glacier has no such power. Consequently, it dropped coarse and fine together and pressed them down in one indiscriminate mass. Such a deposit is called "glacier till" and in it may be seen the striated bowlders which scoured the rocks beneath the ice, together with the clay and sand which are the filings they produced.

REFERENCES.

Rocks, Rock-weathering, and Soils. Merrill. 1897, p. 138.
Elements of Geology. Le Conte. 5th ed. 1904, pp. 69-70.
Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 281-286.

GLACIAL TILL NEAR HIGHLAND

LAKE MOHONK

LOCATION.—Lake Mohonk is situated in a little hollow near the top of the Shawangunk Mountains about 18 miles west of Poughkeepsie. Near the southern end of the lake there is a high cliff known as Skytop, which can be seen for miles around and serves as a landmark to locate the position of Mohonk. (Number on map, 5.)

DESCRIPTION.—Two features of special importance which should be noted. The first of these is the thick mass of white quartz conglomerate or grit, out of which Skytop, Eagle Cliff, the bluffs surrounding the lake, and the piles of huge bowlders are built. This grit surrounds Mohonk on the east, north, and west. The second feature of importance is the soft, dark, thin-bedded shale, which underlies the grit and forms the south shore of the lake. This shale may be seen below the cliffs on the way down the mountain to New Paltz.

EXPLANATION.—Speculation regarding the origin of Lake Mohonk has given rise to much discussion, but it may be briefly stated that before Mohonk existed, erosion had cut a steep, narrow valley through the tough grit down into the soft shale. It is in this valley that the lake now rests. While this valley was still in the process of formation the great ice-sheet invaded the region and took part in the operation. It seems to have done two things; gouged out a hollow in the valley bottom and thrown a mass of debris across the valley from wall to wall. In this hollow and behind the obstruction the lake, fed by rain and springs, has collected. The piles of bowlders referred to above are produced by the disintegration of the cliffs, as explained in another section under Rock Breaking, and have accumulated since the departure of the ice. There has been no volcanic action.

REFERENCES.

N. Y. State Museum. 47th Rept. Darton. 1894, pp. 540-552.
National Geog. Mag. Darton. Vol. VI, 1894, pp. 23-34.
Physical Geog. of N. Y. State. Tarr. 1902, pp. 205-206.

LAKE MOHONK FROM EAGLE CLIFF

KETTLE-HOLE

LOCATION.—This kettle-hole is located on a lane which runs east from the "Creek Road" a quarter of a mile north of the junction of the latter with the State highway, which extends from Poughkeepsie to East Park. (Number on map, 16.)

DESCRIPTION.—The kettle-hole is the oval depression in the plain. It is about 15 feet deep, 50 feet across the top, and 25 feet in diameter at the bottom. The sides slope abruptly inward and downward. The depression has no outlet, and during wet seasons of the year contains a shallow pool, in which aquatic plants have taken up their abode. Surrounding this kettle-hole is a gravel plain.

EXPLANATION.—The origin of this kettle-hole dates back to the Glacial Epoch. As the Ice Age came to an end and the huge ice-cap began to disappear by melting, detached and stranded ice-blocks were left here and there, scattered about the valleys which had been occupied by glaciers but a short time before. The streams which drained the melting glaciers further up the valley ran off the ice-cap heavily loaded with debris, but rapidly deposited this detritus lower down in their channels as their currents were gradually checked. Thus the stream valleys were quickly filled up with sand and gravel, and ledges, rocks and stranded ice-blocks were alike buried beneath this alluvial accumulation. This kettle-hole is the site of one of these buried ice-blocks. After it was covered up it gradually melted away and left a hole where it had formerly rested. The surrounding gravel caved in to fill this depression, until it came to a position of rest, and took the form of a steep-sided, funnel-shaped hollow.

REFERENCES.

An Introduction to Geology. Scott. 1897, p. 155.
Practical Physiography. Fairbanks. 1906, p. 286.
Glaciers of North America. Russell. 1897, pp. 29-30.

KETTLE-HOLE ON BENNETT FARM NEAR POUGHKEEPSIE

HANGING VALLEY

LOCATION.—This is located at the old pin factory, on the west bank of the Hudson about three miles below Highland. The stream which forms the cascade is Crafts Creek. (Number on map, 17.)

DESCRIPTION.—Crafts Creek is a short stream which rises in the back country about five miles from the Hudson, flows in a rather shallow valley, and on reaching the escarpment, plunges in a picturesque cascade 100 feet to the river.

EXPLANATION.—The significant feature about Crafts Creek is that it has not been able to cut its valley down to the surface of the Hudson so as to flow into it at grade, but on the contrary its valley ends abruptly at the top of the escarpment. At one time the Hudson used to flow in the broad valley on a level with the Poughkeepsie bridge, 200 feet or more above its present surface. This was before the gorge was cut. When the Hudson had the course just described, all the streams tributary to it met it at grade. Later, due probably to an uplift of the entire region, the Hudson cut rapidly downward and eroded its present gorge. The larger tributaries, having great erosive power were able to deepen their channels as rapidly as the Hudson, and consequently maintained a corresponding grade. Some of the smaller streams, however, did not have power enough to do this, and consequently were obliged to fall over the brink of the ever-deepening gorge, and reach the river by cascades. Their valleys were thus left suspended in the air as it were, or left hanging. Hence the term "hanging valley." Later, the Hudson gorge was occupied by a glacier which widened it somewhat and cut it still deeper.

REFERENCES.

Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 290-291.
Practical Physiography. Fairbanks. 1906, pp. 315-316.
Physiography. Salisbury. 1907, pp. 245-248.

HANGING VALLEY NEAR MILTON

TERMINAL MORAINE

LOCATION.—The terminal moraine discussed here is located at Haverstraw, and extends from the railroad station southwestward two miles along the base of the mountain. (Outside the area of map.)

DESCRIPTION.—This moraine consists of a low mound, not over 75 feet above the grade of the railroad, a quarter of a mile wide and two miles long. As shown in the railroad-cut near the station, it consists of a red clay mixed with bowlders of various sizes.

EXPLANATION.—When the ice-sheet, which invaded this region during the Glacial Epoch, crept slowly down from the north it advanced its front as far as northern New Jersey and Pennsylvania, where it remained stationary for some time before it began to retreat. While the ice-front occupied this stationary position the debris which had been brought down from the back country, melted out of the glacier and accumulated in a huge mound inclosing the ice-margin. This now forms the great terminal moraine. When this ice-cap began to melt back it did not recede at a uniform rate, but its retreat was interrupted with many pauses and advances over country it had lately vacated. Long after the main body of the ice had melted out of this region there remained a tongue-like glacier occupying the Hudson gorge. This glacier has left records of a complicated history all along its course, and this moraine at Haverstraw is one of them. It records a time when the glacier of the Hudson gorge stood stationary for a short period at the base of the Haverstraw highlands, and dumped its load beneath High Tor in a terminal moraine. It was only a passing episode and soon ceased, but the event occupied time enough to leave an interesting record behind.

REFERENCES.

An Introduction to Geology. Scott. 1897, pp. 113-115.
Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 301-303.
Physiography. Salisbury. 1907, pp. 257-260.

TERMINAL MORAINE AT HAVERSTRAW

RIPPLE-MARKS

LOCATION.—The quarry in which these ripple-marks are to be seen, is situated on the west bank of the Hudson River about opposite the Poughkeepsie pumping station, and 200 yards north of Clearwater, a signal house on the West Shore Railroad. (Number on map, 18.)

DESCRIPTION.—These ripple-marks are wave-like irregularities on the surface of the ledge giving it a corrugated appearance. The ridges are low and wide, the hollows between them shallow and broad, so that the crests of the ridges stand about a foot apart. The surface over which these ripple-marks are developed is about 50 feet high by 50 feet long.

EXPLANATION.—These ripple-marks were formed millions of years ago during the Paleozoic Age. Similar ones are being formed to-day under shallow ocean water not far from shore. Their presence is indicative therefore of shallow water conditions. The rocks of this ledge were originally fine silts and sands, lying in a horizontal position along an ancient seacoast, which could not have been far distant. While they were in this loose condition the surface was rippled, and slowly covered up by the deposition of other sediments on top of it. As these overlying deposits grew thicker the ripple-marked beds were gradually buried deeper, and slowly sank lower and lower into the earth's crust. They were later involved in earth movements, compressed into folds, and elevated to form part of a mountain system which at one time occupied this region. Finally erosion removed the overyling rock cover, and a little blasting in the quarry has exposed the ripple-marks to view in as perfect a condition as when they were first formed.

REFERENCES.

Geology. Chamberlin and Salisbury. Vol I, 1905, pp. 371-373.
An Introduction to Geology. Scott. 1897, pp. 224-225.
Elements of Geology. Le Conte. 5th ed. 1904, p. 39.

RIPPLE-MARKS NEAR HIGHLAND

CURRENT-MARKS

Location.—These current-marks occur in a ledge along the line of the West Shore Railroad about a mile above Highland, and 200 feet south of Clearwater flag station. They occupy the upper part of a cliff about 30 feet above the track. (Number on map, 18.)

Description.—These markings occur in a dark-colored shaly sandstone with its bedding-planes standing in a nearly upright position. Scattered closely over its surface are numerous mounds or humps.

Explanation.—Millions of years ago, during the early part of Paleozoic times, these shales were laid down as mud deposits on the floor of an ancient sea, along the margin of a land-mass which has long since disappeared. The water was shallow, and in all probability uncovered these mud flats and left them exposed at low tide. Across these muddy bottoms the tidal currents moved to and fro, gouging out material here and depositing it there, until the surface was roughened with an irregular system of shallow pits and low mounds. With the advance of the next tide, these irregularities were covered over with a fresh deposit of mud and fine sand, and their cast taken as perfectly as if done by an artist. As these beds were gradually covered with other deposits they sank deeper in the earth's crust and solidified to rock. Later, they were raised and tilted so as to stand on end. They had their cover removed by erosion, and finally were themselves attacked by the same destructive agencies, and their inner structure exposed. The significance of these little mounds is now apparent. They are the casts of the hollows cut by the tidal currents in the mud flats millions of years ago.

REFERENCES.

Manual of Geology. Dana. 4th ed. 1895, pp. 94-95.
Text Book of Geology. Geikie. 3rd ed. 1893, pp. 507-508; 4th ed. 1903, pp. 642-643.
Elements of Geology. Norton. 1905, pp. 178-180.

CURRENT-MARKS NEAR HIGHLAND

STRATIFICATION

LOCATION.—The beds described here are a part of the clay deposit in the big pits of the Rose Brick Company at Roseton, five miles north of Newburg. Examples of stratification may be seen in any part of the excavation. (Number on map, 19.)

DESCRIPTION.—The essential feature to be observed in these clay deposits is the thin, horizontal beds in which the clay is laid down. The bluff shown in the illustration, which is about 30 feet high, is built up of a multitude of these thin sheets of clay laid one on another like leaves of a book.

EXPLANATION.—Stratified deposits are made either by the agency of water or wind. The clays referred to here were made by the former. The coarseness of a formation or the size of the particles entering into the beds depends largely on the strength of the current by which the deposit is made. So from the character of the deposit may be inferred the conditions under which they were made. When a stream bearing detritus enters a standing body of water like a lake, coarse particles are eliminated first and then in succession the finer in proportion as the current slackens its velocity. The finest muds and silts are held in suspension longest but at length they, too, are deposited in the deepest and quietest water beyond the reach of shore currents. These clays of the Roseton pits were laid down under such still water conditions. They date back to the Ice Age when the Hudson gorge was occupied by a glacier. As this glacier melted slowly back, streams loaded with silt ran off its surface to empty into the still water of the Hudson River beyond. There the load was dropped and layer by layer the clay deposit was built up to its present dimensions.

REFERENCES.

An Introduction to Geology. Scott. 1897, pp. 145-148.
Elements of Geology. Le Conte. 5th ed. 1904, pp. 21-22.
Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 486-488.

STRATIFIED CLAY AT ROSETON

UNCONFORMITY

LOCATION.—This unconformity is situated in the New York Central railroad cut on Main Street, Poughkeepsie. The view shows a portion of the west side of this cut immediately south of the bridge. (Number on map, 20.)

DESCRIPTION.—The section consists of two kinds of materials lying one on the other. The lower is a ledge of drab, folded shale. Above, there rests a bluish clay containing bowlders. Where these two formations come in contact there is a sharp line of separation called an "unconformity."

EXPLANATION.—The history of this unconformity is briefly as follows: Back in early Paleozoic times when this region was submerged beneath a shallow sea, mud deposits were laid down precisely as similar beds are forming to-day under the Atlantic. These muds were gradually covered up by sediments and solidified to a solid rock called "shale." While these shales were still in the process of solidification they were flooded and contorted, and afterwards elevated to form part of a mountain system which formerly existed in this region. Gradually these mountains were cut down by erosion and the overlying beds stripped off, until the shales appeared at the surface. Very much later, during the Ice Age, great glaciers crept slowly down from the north and buried this country under thousands of feet of ice. When this ice-cap disappeared it left the clay deposited on the shale. The contact, therefore, of these two formations represents the time which has elapsed from the deposition of the muds in the early Paleozoic sea, down to the formation of the clay during the Ice Age.

REFERENCES.

An Introduction to Geology. Scott. 1897, pp. 269-271.
Elements of Geology. Le Conte. 5th ed. 1904, pp. 187-188.
Geology. Chamberlin and Salisbury. Vol. I, 1905, p. 15.

UNCONFORMABILITY NEAR MAIN STREET IN POUGHKEEPSIE

JOINTS

Location.—The example chosen here for discussion occurs in the south wall of the Clinton Point Stone Company's quarry at Stoneco, near the localities described to illustrate Dip and Rock-weathering. (Number on map, 4.)

Description.—The ledge is about 15 or 20 feet high and composed of drab-colored limestone, with a surface more or less weathered by the atmosphere. It is traversed by three sets of fractures, which run at right angles to each other, and between them divide the ledge into rough cubical blocks.

Explanation.—These beds date back to early Paleozoic time. When first deposited they were of the consistency of lime-mud or slime, but gradually solidified as they were buried beneath other sediments deposited above them. While in this position, they were affected by earth compressions and tensions which none of the rocks escape. They were twisted and folded, and lifted out of their original position as they were forced up to form a part of the Taconic Mountain system, which once dominated this region. Compact rocks cannot experience such movements without giving way to the tensions and compressions which accompany them. The adjustment of the rocks to these strains produces joints. At first these joints are simply partings, but sooner or later they are apt to be opened by solution, faulting, or other causes and may be utilized by the underground waters for the deposition of ores. In this quarry joints have both been opened by weathering, as shown in the illustration, and closed by the deposition of mineral matter, as explained in the section on Rock-weathering. Joints, when regular and not too abundant, are of great utility in quarrying operations.

REFERENCES.

An Introduction to Geology. Scott. 1897, pp. 262-265.
Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 510-514.
Elements of Geology. Norton. 1905, pp. 216-217.

JOINTS IN LIMESTONE AT STONECO

QUARTZ VEIN

Location.—This quartz vein is located on the estate of Henry Webendofer, about 100 feet from the Hyde Park road and in plain view from it. (Number on map, 21.)

Description.—The outcrop shows a mass of white quartz about three feet wide and three or four feet high, enclosed between two nearly vertical walls of dark-colored sandstone. On either side of the main vein just described may be seen lesser veins of the same quartz material, which run out in all directions and finally disappear in the body of the sandstone ledge.

Explanation.—A vein is a fissure in the earth's crust which has been filled with mineral matter. In the case under discussion the opening was formed and filled some distance within the earth, and has been brought to the surface through the removal of overlying rocks by means of erosion. The fissure may have opened gradually or suddenly, but once open the process of filling began. It is a well-known fact that the rocks, down to a considerable distance within the earth, are saturated with water which is slowly percolating through them. These underground waters act as chemical reagents and profoundly affect the rocks through which they pass. From one rock they will dissolve a mineral and deposit it in another, only to repeat the process later. Fissures, such as shown in the illustration, have always been favorite places for mineral deposition. The quartz in this vein may well have been dissolved from the very ledge in which the fissure occurs, as that mineral is the most important constituent in the surrounding rock.

REFERENCES.

Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 427-428.
Outlines of Field Geology. Geikie. 1896, pp. 183-187.
An Introduction to Geology. Scott. 1897, pp. 265-268.

QUARTZ VEIN ON WEBENDOFER ESTATE
NEAR POUGHKEEPSIE

DIP

Location.—Perhaps as striking an example of dip as can be given is that shown in the figure. It occurs in the south wall of the quarry at Stoneco near the locality described under Rock-weathering. (Number on map, 4.)

Description.—This ledge is about 75 or 100 feet high and composed of limestone. In the escarpment, which is produced artificially by quarrying, the beds may be noticed inclining downward toward the lower right-hand corner of the illustration. This sloping of the strata is known as "dip."

Explanation.—With certain exceptions which need not be discussed here, it may be accepted as a general rule that all sedimentary beds are deposited in a horizontal position. If they are now found resting in any other attitude it shows that they have suffered displacement to an amount varying with the angle at which they lie. This displacement is expressed in degrees, and is termed the "dip" of the beds. Strata are folded or contorted in various degrees, and in proportion to the ability of the rocks themselves to withstand compression. Limestones will rise and fall in great folds, while shale will crinkle like tissue paper. Where compression has been most severe, beds have been raised on end to a perpendicular position, and then turned over so as to lie flat again, but in an inverted position. Such overthrows are not uncommon in highly folded mountain regions like the Alps and Rocky Mountains. As this region was once part of a highly folded mountain system, the origin of the dip in the Clinton Point quarries is readily understood, for these limestones are remnants of huge folds.

REFERENCES.

An Introduction to Geology. Scott. 1897, pp. 232-233.
Elements of Geology. Le Conte. 5th ed. 1905, pp. 184-185.
Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 500-501.

DIP IN STRATA AT STONECO

ROCK FOLDING

LOCATION.—The fold is located on the west bank of the Hudson, along the road running parallel to the West Shore Railroad tracks, about 200 yards south of the Poughkeepsie Bridge pier. It may be distinctly seen in the ledge on the west side of the road almost on a level with the highway. (Number on map, 22.)

DESCRIPTION.—The rocks in which this fold occurs are made up of interbedded sandstones and shales, which, when fresh, have a bluish-brown color. The height of the fold is about eight feet, the length about thirty.

EXPLANATION.—The various beds of shale and sandstone which constitute this ledge were deposited during the early part of the Paleozoic Era in shallow water not far from land. In their original position they were laid down horizontally. As years passed by and more sediments were heaped upon the beds deposited earlier, the lower strata sank deeper and deeper within the earth's crust and finally became buried under several thousand feet of material. At the same time these deposits were slowly undergoing another change. The loose particles of which they were composed were pressed closer and cemented together to make solid rock. Later there came a change, which may have begun while this cementing process was still in progress. Due to earth forces these beds were compressed and buckled up into folds so as to form an extensive mountain system. Finally, erosion acting through long periods of time, has cut these mountains down again almost to sea-level. The small fold shown in this figure and described above, is one of the minor corrugations, but in its form and development, may be taken as typical of others of much greater dimensions.

REFERENCES.

Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 501-510.
An Introduction to Geology. Scott. 1897, pp. 233-242.
Text Book of Geology. Geikie. 3rd ed. 1893, pp. 536-543; 4th ed. 1903, pp. 672-681.

ROCK FOLDING NEAR HIGHLAND

DIFFERENTIAL CLEAVAGE

LOCATION.—The ledge in which this differential cleavage occurs is situated on the West Shore Railroad, about a mile above Highland and 200 yards north of Clearwater flag station. (Number on map, 18.)

DESCRIPTION.—This ledge is about 15 feet high and composed of alternate beds of dark-colored sandstone and shale. In the view the sandstone appears as a massive rock, while the shale bands are thinner and fractured, with the lines of fracture standing in a nearly perpendicular attitude.

EXPLANATION.—These sandstone and shale beds were originally deposited as alternate layers of sand and mud on the bed of the early Paleozoic sea. In all probability they were laid down in shallow water only a short distance from shore. After they were deposited they were covered up with other sediments and gradually buried deep in the earth's crust. During all this time this loose material was slowly being converted into solid rock. The sand changed to sandstone and the mud to shale. At some time in their history, it is impossible to say just when, but while they were still buried deep within the earth, these rocks were subjected to great pressure. Under the influence of this compression the shales yielded more than the sandstones. The former developed cleavage-planes as a result of this yielding, while the latter remained massive. These beds have since been uncovered and brought to the surface, while weathering has accentuated these lines of cleavage and brought them prominently to view. They are the perpendicular lines of fracture referred to above. A little examination will suffice to show that they are confined to the shale, and end at its contact with the sandstone.

REFERENCES.

Elements of Geology. Le Conte. 5th ed. 1904, pp. 189-196.
Text Book of Geology. Geikie. 3rd ed. 1893, pp. 312-314; 4th ed. 1903, pp. 417-419.
Elements of Geology. Norton. 1905, pp. 207-208.

DIFFERENTIAL CLEAVAGE NEAR HIGHLAND

FAULTED STRATA

LOCATION.—This fault occurs in the face of a ledge just south of Ennis' Cut flag station on the western shore of the Hudson, about a mile north of Highland, and nearly opposite the Seminary of St. Andrews. (Number on map, 18.)

DESCRIPTION.—The fault is the break in the continuity of the shales, and extends down the illustration from the upper left-hand corner to the bottom of the ledge. On the northern or right-hand side of this fault the bedding-planes of the rocks lie almost horizontal, while on the opposite side they are bent up as they approach the fault line.

EXPLANATION.—All the rocks within the earth are under more or less strain arising from the adjustment of equilibrium in the crust. These strains accumulate until the elastic limit is exceeded when the rock breaks along a sinuous line and beds formerly continuous are cut asunder and slip apart. In faulted rocks the beds are mutually displaced so that one side has been thrown down or shoved up in relation to the other. If in the view the beds are examined on both sides of the fault it will be seen that they do not match. A stratum on one side is opposed by a different stratum on the other. This proves displacement. Another thing will also be noticed. On the left-hand or down-thrown side the beds will be seen to curve up near the fault. When this block was forced down its edge was retarded by friction as it scraped against the opposing face of the other block; this friction caused them to bend up as shown in the figure. Such slips generate vibrations which produce destructive earthquakes. Charleston, San Francisco, and Kingston have furnished us with striking examples.

REFERENCES.

An Introduction to Geology. Scott. 1897, pp. 243-259.
Elements of Geology. Le Conte. 5th ed. 1904, pp. 237-243.
Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 514-525.

FAULTED STRATA NEAR HIGHLAND

SLICKENSIDES

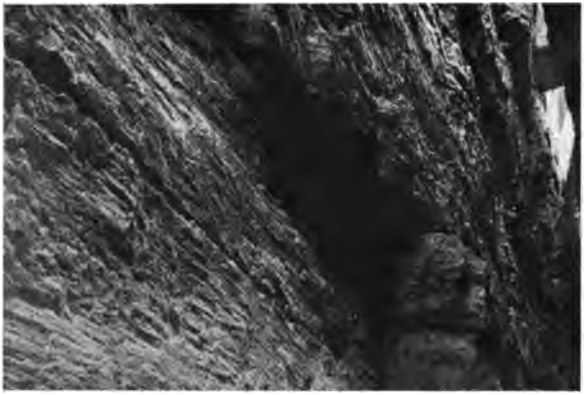
LOCATION.—The slickensides described here occur in the "crevice" on the southern point of the cliff at Lake Mohonk. In this chasm they may be distinctly seen on either wall. The figure shows a portion of the north wall about 100 feet below the top of the cliff. (Number on map, 5.)

DESCRIPTION.—These slickensides are the parallel grooves or scratches which extend across the face of the wall in an east and west direction, and in a nearly horizontal position. They might easily be mistaken for glacier striæ, which they closely resemble.

EXPLANATION.—At a time so remote that it is impossible to accurately express it in years, the rocks which build up the Shawangunk Mountains and all the surrounding region were deeply buried in the earth's crust. While they were thus covered up under thousands of feet of overlaying materials, they were subjected, for long periods of time, to great pressure arising from the slow adjustment of the crust. These adjustments were accompanied by movements of huge rock-masses as they parted along lines of weakness and were gradually shoved past each other. During these movements they were in such close contact that their sides ground together and left long parallel gouges where the harder parts of one were forced into the softer parts of the other. Thus this peculiar grooving was introduced. Since that time erosion has removed the overburden of sediments, cut the rocks under discussion into mountains and valleys, and finally this "crevice" has opened, disclosing the slickensides within, as a huge rock mass has become separated from the main ledge.

REFERENCES.

An Introduction to Geology. Scott. 1897, pp. 243-246.
Elements of Geology. Le Conte. 5th ed. 1904, p. 243.
Rocks, Rock-weathering, and Soils. Merrill. 1897, pp. 53-54.



SLICKENSIDES AT LAKE MOHONK

CLAY DEPOSIT

LOCATION.—This deposit occurs at Roseton, on the western shore of the Hudson about five miles north of Newburg, where there are extensive clay pits worked by the Rose Brick Company. (Number on map, 19.)

DESCRIPTION.—In the largest of these excavations at Roseton the clay deposit is about 150 feet high and 400 feet wide. It is drab in color, fine-grained, deposited in thin layers, and burns in the kiln to a bright red.

EXPLANATION.—This deposit is located on the side of the steep inner valley-wall or gorge of the Hudson. The rocks through which the river has cut its way are very old, while the clay beds deposited against them are very young. It is therefore evident that the Hudson gorge must have been excavated before the clays were laid down. While the Hudson was at work carving out its present channel this entire region was overwhelmed by a great ice-sheet which crept slowly down from the north, and covered beneath its surface all traces of land in this vicinity. As this ice-cap slowly disappeared from this district, there was left behind a long tongue-like glacier occupying the Hudson gorge. This in turn slowly melted back, halting from time to time in its retreat, and finally vanished altogether. The clay deposit shown here seems to have been made at the southern end of the glacier when the margin rested near the present site of Roseton. Streams running off the surface of the melting ice were loaded with fine rock-waste, and dropped this detritus at the end of the glacier in the deep quiet waters which filled the gorge to a greater height than at present. The conditions in the gorge near the terminus of the glacier were in all essential details the same as in a lake, and in this lake-like river the silt was deposited in great beds of clay.

REFERENCES.

Manual of Geology. Dana. 4th ed. 1895, pp. 80-81.
An Introduction to Geology. Scott. 1897, pp. 269-271.
Rocks, Rock-weathering, and Soils. Merrill. 1897, pp. 137-138.

CLAY DEPOSIT AT ROSETON

SHALE

Location.—Shale is the most common of the rocks in this vicinity. The particular example figured here occurs in the side of a low mound in the open field at the southwest corner of Raymond and College View Avenues. (Number on map, 23.)

Description.—This low hillock or mound which rises above the general level of the surrounding flat country, is composed entirely of shale except for a thin cap of soil on the top and sides. The rock is dark brown to black in color, is quite soft, and breaks readily into thin flakes or chips.

Explanation.—Shale is a hardened mud just as sandstone is a sand deposit changed to stone, and a conglomerate is a gravel bed solidified to rock. Back in Paleozoic times before North America had assumed its present form, there existed in this vicinity an ancient land-mass the outline and extent of which are not perfectly known. From its elevated portions rivers ran down to the sea bearing the products of rock decay in the form of mud, and other detritus. On reaching the ocean this material was spread out along the beach and worked over by the waves. These mud beds were then gradually covered over by other deposits and slowly depressed so as to sink down and become a part of the earth's crust. Under the great pressure of overlying formations and also due to the cementing activity of underground waters, these soft mud deposits gradually became solidified to a rock known as "shale." These shales were afterwards elevated again toward the surface of the earth, the overburden stripped off by erosion and the rocks exposed to the atmosphere, where they are again undergoing erosion.

REFERENCES.

An Introduction to Geology. Scott. 1897, pp. 207-208.
Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 432-436.
Rocks, Rock-weathering, and Soils. Merrill. 1897, pp. 137-138.

SHALE LEDGE AT VASSAR COLLEGE

CALCAREOUS TUFA

LOCATION.—This tufa deposit occurs north of Newburg on the west side of the river road about half way between Balmville and Roseton. At this point a little stream of water trickles down the face of an embankment and just before reaching the gutter is collected in a long iron pipe and led into a drinking-trough standing on the roadside. (Number on map, 24.)

DESCRIPTION.—The calcareous tufa is a yellowish, porous-looking substance, deposited at the base of the embankment and for some distance up the stream. It is thickest and most extensive, however, in the vicinity of the drinking trough. On examination the tufa will be found to contain incrustations of moss, and leaves of deciduous trees.

EXPLANATION.—A deposition of tufa is the sequel of the formation of limestone caverns. In forming caverns lime is carried away in solution by underground water. In forming tufa this same lime is reprecipitated by the underground waters as they issue at the surface in springs. As the stream in the illustration issues from a limestone ledge at the top of the escarpment, it at once begins to evaporate and precipitate its load. The lime which was invisible while held in solution appears in the form of minute whitish particles which attach themselves to rocks, vegetation, and other objects in their reach and rapidly cover them with an incrustation called "tufa." Perfect impressions are taken and later, when the vegetable matter decays, casts of the most delicate character are left behind.

REFERENCES.

Elements of Geology. Le Conte. 5th ed. 1904, pp. 78-80.
Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 222-223.
Rocks, Rock-weathering, and Soils. Merrill. 1897, pp. 111-112.

CALCAREOUS TUFA LOCALITY NEAR NEWBURG

UNFOSSILIFEROUS LIMESTONE

LOCATION.—Cedar Ridge furnishes the limestone ledge discussed in this section. It is situated about one mile east of the College on the Hackensack road, and forms the divide between Casper and Wappinger Creek valleys. (Number on map, 25.)

DESCRIPTION.—A limestone precipice may be seen along the western face of the ridge just before the road passes over the divide into the valley of Wappinger Creek. The rock is covered with lichens, and has weathered to a dark brown or black, which gives a mottled appearance to its scarred and irregular surface. On the crest of the ridge fresh surfaces of limestone may be seen. The rock is light drab to buff in color, and unfossiliferous. Its stratified appearance has been obscured by severe crushing.

EXPLANATION.—Limestone is a sedimentary rock of marine origin deposited on the bed of the ocean at considerable distance from land. On the floor of the ocean within the zone of lime formations, little continental detritus enters except along the outer margin, but the open sea is the source whence its materials are derived. Corals, sea-urchins, shell fish, etc., which secure the lime for their skeletons from sea water, flourish on the bottom in countless millions, and on dying give their hard parts back to the sea. This mass is slowly buried up and cemented by lime to a fossiliferous limestone, or in certain areas where the lime accumulated without the intervention of marine life, or where the remains of such have been obliterated, the resulting limestone will be unfossiliferous. The Paleozic limestone of Cedar Ridge seems to have been formed under the latter conditions.

REFERENCES.

Rocks, Rock-weathering, and Soils. Merrill. 1897, pp. 143-146.
Manual of Geology. Dana. 4th ed. 1895, pp. 78-80.
Text Book of Geology. Geikie. 3rd ed. 1893, pp. 149-150; 4th ed. 1903, pp. 190-192.

LIMESTONE OUTCROP ON CEDAR RIDGE
NEAR POUGHKEEPSIE

FOSSILIFEROUS LIMESTONE

LOCATION.—These limestones form a part of the workings of the Newark Lime and Cement Company at Rondout. The quarry is situated on the north side of Delaware Avenue near a turn in the road, and directly opposite an abandoned shaft house. (Number on map, 26.)

DESCRIPTION.—The quarry rock is a bluish-grey limestone containing fossils of corals, crinoids, and brachiopods, and interbedded layers of flint nodules. Fossils are abundant in this quarry, and along the limestone ledge to the north especially in the rocks of the escarpment facing the Hudson River. In collecting, however, care must be taken to examine the older, weathered rock surfaces, for on these the fossils will be found standing out in relief. Fresh rock faces seldom show their fossil contents well.

EXPLANATION.—The limestones in this quarry were deposited during the early part of the Paleozoic period in clear seas of considerable depth, and so far distant from large masses of land as to lie beyond the influence of the muddy sediments which surround every continent. On the bottom of this ancient sea corals, crinoids, brachiopods, and other marine animals flourished in countless numbers. In course of time they died, and their soft fleshy parts rapidly decayed, leaving the hard stony skeleton behind. These skeletons were gradually buried up by the slow accumulation of lime, and fossilized when the lime sediments solidified to rock. Thus is preserved a record of very ancient life, and from these fossils and others similar to them, much has been learned regarding former life, and the conditions under which it existed.

REFERENCES.

An Introduction to Geology. Scott. 1897, pp. 342-354.
Elements of Geology. Le Conte. 5th ed. 1904, pp. 198-202.
Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 646-648.

FOSSILIFEROUS LIMESTONE AT RONDOUT

BRECCIATED LIMESTONE

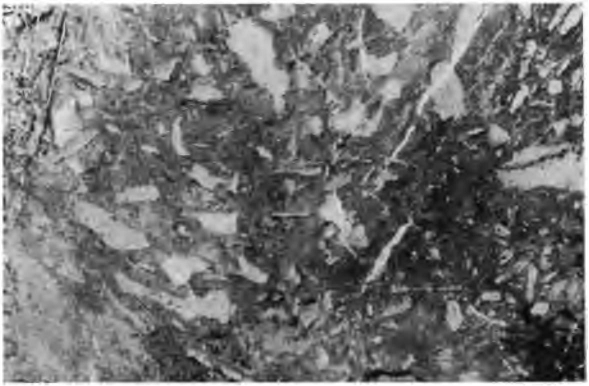
LOCATION.—This breccia occurs on the farm of Alfred Welch in Eighmyville, at the same locality as that given for the Limestone Cavern. It is in fact within this rock that the cave has been excavated. (Number on map, 7.)

DESCRIPTION.—This breccia consists of angular fragments of limestone bound together with calcite. The view illustrates this angular character of the fragments very clearly. The light grey irregular blotches are sharp-cornered blocks of limestone, and the dark grey ground-mass is the calcareous matrix in which they are imbedded. The whole constitutes the breccia.

EXPLANATION.—Two things are to be accounted for in this formation; the presence of the limestone blocks, and their angular character. In discussing the Quartz Conglomerate it was shown that the fragments which constituted it were derived from ledges on a neighboring land-mass, but were rolled about and rounded on the ocean beach by the waves. The history of this breccia is somewhat different. These angular blocks were obtained from some limestone ledge which probably stood out as an ancient headland on an unprotected coast. Limestone is much softer than quartz, and consequently more readily rounded. Therefore it is evident that these angular blocks could not have been transported far by rivers, or moved about long on the shore. It is probable then, that as soon as these fragments were torn from the headland by the breakers they fell at once into deep water beyond the reach and influence of the waves. In their new position they were gradually buried beneath sand, and the whole eventually bound together by lime to form a solid rock. This formation together with the rest of this region, was later raised to its present position, and uncovered by erosion.

REFERENCES.

An Introduction to Geology. Scott. 1897, p. 206.
Rocks, Rock-weathering, and Soils. Merrill. 1897, p. 137.
Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 422-424.



BRECCIATED LIMESTONE AT EIGHMYVILLE

QUARTZ CONGLOMERATE

LOCATION.—The particular bowlder figured here came from the cliff about Skytop, but is chosen for convenience of location. It is situated on the south side of the Spring House, on the Lake Drive at Mohonk. It may be readily identified by the cross-fractures in the upper right-hand corner. (Number on map, 5.)

DESCRIPTION.—In this bowlder the essential features to be noted are first, the whitish character of the rock as a whole and second, the smooth well-rounded quartz pebbles of which it is composed. These pebbles, which vary somewhat in size, are distributed in rough beds or layers. The whole rock looks like a solidified gravel bed.

EXPLANATION.—The ledges of conglomerate which cap the Shawangunk Mountains, were once a beach deposit on the margin of the Paleozoic sea. Beach building is simply a concentration of hard particles, and an elimination of the soft ones. Breakers beating against exposed sea cliffs tore off masses of rock, and rivers brought to the ocean quantities of mud and sand. This debris was seized by the waves which rolled it about and ground it together, until all the soft particles were carried off to deep water by the undertow, and the tougher quartz pebbles left behind to form the beach. In this process all the sharp corners and angles were rubbed off. This beach deposit sank beneath ocean level, and was gradually covered up by other beds which were deposited above it. During all this time it was slowly being solidified, and changed from a loose deposit of sand and pebbles to a solid conglomerate. Later it was raised again, the overburden stripped off, and the conglomerate itself eroded to its present outlines.

REFERENCES.

Rocks, Rock-weathering, and Soils. Merrill. 1897, p. 133.
An Introduction to Geology. Scott. 1897, pp. 116-119.
Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 355-356.

QUARTZ CONGLOMERATE AT LAKE MOHONK

TRAP ROCK AND TALUS

LOCATION.—Trap rock occurs in the Palisades on the west bank of the Hudson, all the way from Jersey City to Haverstraw. The particular portion of this extended area chosen for discussion here occurs on the Hudson one mile south of Haverstraw, under the shadow of High Tor, and just before the road passes into Short Clove. (Outside the area of map.)

DESCRIPTION.—Two things are to be noticed in this place; the perpendicular cliff of dark brown trap rock occupying the upper half of the escarpment, and the long slope of rock debris beneath it, where huge blocks are wedged together at all angles and in great confusion.

EXPLANATION.—The trap rock forming the upper cliff is volcanic. Its origin dates back to Mesozoic time, when huge reptiles were the dominant types of animal life. At that time the region now occupied by the Palisades was beneath the sea, and receiving deposits of mud and sand from neighboring land areas. While these beds were in process of formation, volcanic disturbances occurred, and vast quantities of lava were forced up from below, and intercalated in huge sheets between the layers of sandstone. There it cooled and hardened to solid rock. Subsequent elevation and denudation of the overlying beds has brought this trap rock to the surface, where it maintains itself in the picturesque cliffs or Palisades. All rocks yield to the influences of the weather, and trap is no exception. Slowly the Palisades are crumbling, and in time will disappear. The rate of this destruction is recorded in the talus slope at the base of the escarpment.

REFERENCES.

An Introduction to Geology. Scott. 1897, pp. 80-82.
Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 110-113.
Rocks, Rock-weathering, and Soils. Merrill. 1897, pp. 88-89.

TRAP ROCK AND TALUS NEAR
HAVERSTRAW

SLATE

LOCATION.—The quarry in which these slates occur, is situated on the west bank of the Hudson River about opposite the Poughkeepsie pumping station, and 200 yards north of Clearwater flag station on the West Shore Railroad. The quarry is now abandoned. (Number on map, 18.)

DESCRIPTION.—The slates of this quarry are exposed over a broad surface about 50 or 75 feet high by 100 feet long, and stand upright in a nearly perpendicular position. They are dark drab in color, with here and there reddish blotches produced by iron stains.

EXPLANATION.—These slates have a prolonged and complicated history. They first existed in the form of muds, which were deposited on the bottom of an ancient sea, dating back into early Paleozoic time. After they were deposited they were covered up with other materials, and gradually changed from loose mud to solid rock. Such a formation is known as "shale." While these shales were still deeply buried within the earth's crust, they were subjected to great compression and squeezing, due to rock folding attendant on the growth of the Taconic mountains. In regard to these mountains it may be said that they were uplifted early in Paleozoic time, and formerly dominated this entire region. The pressure to which these shales were subjected, gradually produced an important change in their microscopic structure, so that in place of splitting most readily along their bedding-planes, they now parted more easily in other directions at an angle to the original stratification. It is this property of cleaving most readily at an angle to the bedding-planes, which distinguishes a slate from a shale.

REFERENCES.

An Introduction to Geology. Scott, 1897, pp. 260-262.
Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 440-443.
Rocks, Rock-weathering, and Soils. Merrill. 1897, p. 137.

SLATE QUARRY NEAR HIGHLAND

MARBLE

Location.—The best place in this vicinity to study the formation of marble is at the quarries of the South Dover Marble Company. This quarry is situated in a valley about one mile east of South Dover. (Outside the area of map.)

Description.—The excavation shown in the illustration has been made in a white, fine-grained marble which is used principally for exterior work in New York City and elsewhere. Large blocks are removed from the quarry, and transported by trolley to Wingdale, where they are cut by machinery, and dressed to the required dimensions for market.

Explanation.—Marble is a limestone deposit which has been so altered by heat as to lose its sedimentary character, and become crystalline. In its formation the first step was the deposition of an extensive bed of limestone on the floor of the ocean, as described in the section on Limestone. This limestone was then slowly buried, and depressed so as to pass down and become incorporated in the crust of the earth. After the lapse of long periods of time it was elevated, and folded into a portion of the Taconic mountain system, the eroded remnants of which may be seen in the Fishkill Mountains, and other hills in this vicinity. During this process of mountain uplift with its attendant compression and crushing, there was produced considerable heat. This limestone, saturated with superheated water, was brought to a high temperature, and the conditions were favorable for its metamorphosis to a marble. Volatile hydrocarbons were driven off, inorganic impurities were transformed to pyrite, tremolite, and other minerals, and the limestone itself assumed a granular crystalline character.

REFERENCES.

Rocks, Rock-weathering, and Soils. Merrill. 1897, pp. 162-163.
Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 446-448.
Elements of Geology. Le Conte. 5th ed. 1904, p. 231.

MARBLE QUARRY AT SOUTH DOVER

CRYSTALLINE ROCK

Location.—Crystalline rocks are common through the Highlands south of Fishkill, and may be seen everywhere on the top of Mt. Beacon, but in order to have some definite locality for discussion, the ledge shown on the opposite page was selected. It occurs on Mt. Beacon, east of the Casino. (Number on map, 27.)

Description.—This rock is massive, with a mottled appearance, and is composed of three minerals; quartz, which is white and glassy; feldspar, which is pink, and hornblende, which occurs in little black, splintery, crystals.

Explanation.—Crystalline rocks are the antithesis of sedimentary. The former are composed of innumerable crystals interlocked so as to form a solid mass, the latter is built up out of beds or thin sheets of detritus, which has been brought from a distance, and deposited in systematic order. Crystalline rocks have at one time in their history been in a molten condition or magma, from which they have solidified to their present state. When a magma cools, its various constituent elements tend to group themselves in definite compounds to form minerals. What these minerals will be, their size, composition, and distribution, are factors depending on the physical and chemical properties of the magma. Certain molten rock solutions will yield a granite under one set of conditions, and an obsidian under another. If the magmas remain beneath the surface, and cool slowly at great depths, they yield a rock which is wholly crystalline; if, however, they are forced to the surface, and flow out as lava, they cool so quickly that complete crystallization is impossible. The magma freezes, as it were, to a glass in which are imbedded the crystals brought up from the depths.

REFERENCES.

An Introduction to Geology. Scott. 1897, pp. 186-196.
Elements of Geology. Le Conte. 5th ed. 1904, pp. 211-214.
Geology. Chamberlin and Salisbury. Vol. I, 1905, pp. 401-403.

CRYSTALLINE ROCKS ON MT. BEACON

QUARTZ CRYSTALS

LOCATION.—The quartz crystal formation discussed here is situated at Lake Mohonk, on the way to Skytop, where the mountain road bends around the southern point of the cliff. (Number on map, 5.)

DESCRIPTION.—The crystals occur in great quantities in the crevices, and on those faces of the ledge which are stained brown with iron rust. They consist of little hexagonal columns capped with a sharp six-sided pyramid, and look like cut glass.

EXPLANATION.—It was noted above that the crystals occur only on those rock faces which have been discolored with iron stain. The reason for this is not difficult to understand. The discolored surfaces and crevices are ancient partings in the ledge which have been utilized so long as lines of flow by the underground waters, that they have become not only coated with iron, but also bristling with quartz, which has crystallized out from these underground waters. The rock of which the ledge is composed is a conglomerate made almost exclusively of quartz pebbles. Subterranean waters circulating through this rock, have dissolved some of the silica, which is the constituent of quartz, and in meeting these partings have precipitated it again in the form of crystals. These crystals, on careful examination, may be seen in all stages of growth. They start first as minute sparkling points attached to the rock wall, and from that grow in length, and increase in diameter, until the sides of the crevice literally bristle with them. If this precipitation continues long enough the crystals, growing out from either side, will finally interlace, and completely close up the opening with a little vein of solid quartz. By examining the crevices carefully all stages of vein filling may be seen.

REFERENCES.

System of Mineralogy. Dana. 6th ed. 1892, pp. 183-192.
Text Book of Mineralogy. Dana. 1897, pp. 324-328.
Minerals and How to Study Them. Dana. 1895, pp. 274-282.

QUARTZ CRYSTAL LOCALITY AT LAKE MOHONK